Infrared-Image Processing for the DLR FireBIRD Mission

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Abstract. The release of greenhouse gases and aerosols from fires has a large influence on global climate: on average, fires are responsible for up to 30% of anthropogenic CO_2 emissions.
The German Aerospace Center (DLR) is operating the "FireBIRD" constellation, which consists of the two satellite missions TET-1 (Technology Test Platform), and BIROS (Bispectral Infrared Optical System) It is dedicated to scientific investigation of the issues involved as well as to early fire detection from space. The satellite and detector approach is based on proven DLR technology achieved during the BIRD (Bispectral Infrad Detection) Mission, which was launched in 2001 and was primarily used for observation of fires and volcanic activity until 2004. The Payload of TET-1 and BIROS has spectral channels in visible (VIS), near infrared (NIR), mid wave (MIR) and a thermal infrared (TIR) channel. The paper is focused on the processing for TET- and BIROS- Fire- BIRD image data. In the FireBird standard processing chain level 1b and 2a data-products are generated automatically for all users after the data reception on ground. The so called fire-radiative-power (FRP) is one of the most important climate relevant parameters witch is estimated by using the bi-spectral method. Two characteristics of the FireBIRD sensors are unique: first, the high radiometric dynamic sensitivity for quantitative evaluation of normal temperatures and high temperature events (HTE) in the same scene. Second, the evaluation of the effective fire area in square meters independent of the recorded number of fire cluster sizes, which is given as the number of pixels per cluster. For certain users, such as firefighters, it is necessary to obtain fire data products (location and temperature) quickly and with minimal delay after detection. In such applications, data processing must take place directly on board the satellite without using a complex processing chain. The paper describes also an alternative fire-detection algorithm witch uses artificial neural networks (deep learning) and will compare it with the standard Level-2 FireBIRD processing.

Keywords: Small Satellite Constellation, Infrared Instruments, High Temperature Events, Bi-Spectral Method, Artificial-Neural-Networks.

1 Introduction

FireBird is defined as a constellation of two small satellites mainly dedicated to the investigation of high temperature events. The first satellite TET-1 was launched on 12 June 2012. The second satellite BIROS was launched on 22 July 2016.

Both satellites have an identical infrared payload with special design items for detection and measurement of high temperature events in sub-pixel resolution. The payload design is shown in Fig. 1, its main parameters are listed in Table 1.

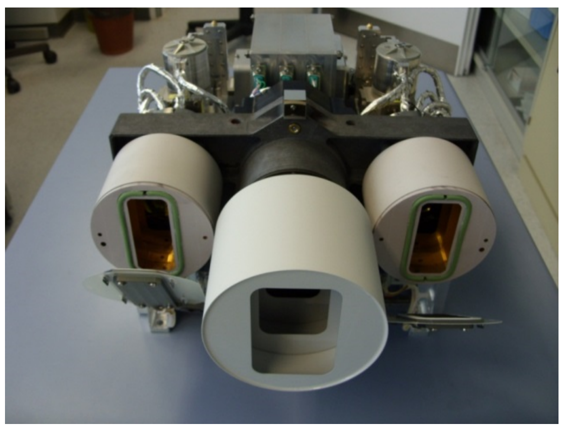

Fig. 1. FireBird camera complex(3 Sensor system; left:MWIR, right LWIR, middel: VIS

Compared to TET-1 the BIROS Satellite is equipped with a propulsion system to ensure an optimal constellation of the orbits to ensure optimal pointing capabilities. In addition BIROS has a much more powerful data processing system on board, which enables the implementation of a very flexible processing chain.

Due to the limited resources of a small satellite, there are some limitations that can be partially compensated by a flexible operation of the satellite. A well-developed service on demand, especially in the case of BIROS, can significantly improve the satellite's data throughput. All these aspects of using a small satellite to study high temperature events (HTE) are explained below.

Table 1. FireBird camera parameters.

	CCD line-VIS Camera (3 line FPA)	Infrared-Cameras
Wave length	1 460 - 560 nm 2 565 - 725 nm 3 790 - 930 nm	MWIR: 3,4 - 4,2 μm LWIR: 8,5-9,3 μm
Focal length	90,9 mm	46,39 mm
FOV	19,6°	19°
F-Number	3,8	2,0
Detector	CCD-line	CdHgTe staggerd Arrays
Detector cooling	Passive, 20 ° C	Stirling, 80 - 100 K
Pixel size	7 μm x 7 μm	30 μm x 30 μm
Number of Pixel	3 x 5164	2 x 512 staggered
Quantization	14 bit	14 bit
Ground sampling distance Ground resolution	42,4 m$^{2)}$ 42,4 m $^{2)}$	356 m $^{2)}$ 178 m $^{2)}$
Swath width	211 km $^{2)}$ km	178 km $^{2)}$
Data rate	max 44 MBit/s nom 11,2	0,35 MBit/s
Accuracy	100m on ground	100m on ground

2 Remote Sensing and Detection High Temperature Events with small satellites

The temporal and spatial distribution of high temperature events (HTE) and the intensity of the events, including their background to the HTE to be taken into account for the analysis, can vary considerably. In Oertel [6] different scenarios were examined with regard to the satellite instruments available at that time. Different observation scenarios are triggered not only by the different types of HTEs, but also by the different types of user groups. In this context it is worthwhile to continue the investigation of the advantages and disadvantages of small satellites begun in Lorenz, [5].

For the investigation of such highly dynamic events as bushfires in particular, the re-visit time and the overflight time of the satellite is an important evaluation criterion. Due to the piggy back launch of small satellites the possibility choosing the over-flight-time (LTAN) is limited. The probability to get an ascending node of about 12:00 o'clock or later (A-Train) is very low, but it is needed to have the possibility to detect and evaluate mostly larger fires like the Aqua- and Terra-Satellites from the USA. TET-1 and BIROS have an equator crossing time of 10:30 am and 9:30 am. From these orbits particularly small fires, which develop in the morning, can be detected. The variability is higher with regard to the revisit time. In a standard flight mode (only nadir pointing orientation, without consideration of the off-nadir pointing options), the TET-1 revisit time is approx. 3 or 4 days (maximum at the equator). The second BIROS satellite was able to reduce this time to 1 day.

Additionally the pointing capability of the satellites with a tilting of up to 30° off track can be taken into account. (The 30° limit is due to the atmospheric damping, not from the satellite). The sub-satellite point moves from day to day about 600 km, but it is possible to obtain an overlap of the image strips of two consecutive days in the order of 100 km by tilting the satellite out of the nadir direction.

With this it is possible to observe a high-temperature event (HTE) in two subsequent days with one satellite. With a second satellite, it would be possible to ensure more than one daily coverage for a given target. This is valid if only night or day time imaging tasks had been taken into account. But in combination of both it is possible with respect to the given orbit constellation to get up to two images of the same target per day. This was demonstrated in different cases.

Another important point is downlink capacity due to limited resources of small satellites. typically equipped with S-Band transmitter. This allows transmitting approximately 100MB per contact (with the best elevation). Using the maximum number of spectral bands, FireBird (TET or BIROS) generates more than 100MB, so more than one contact is required to transmit the data completely.Coming back the detection of HTEs itself, most satellite-based methods rely on sensors witch a channel in the middle infrared (MIR) atmospheric window. As shown in different other publications (e.g. Lorenz [5]) the MIR spectral channel is the most sensitive to active fires, as it includes the spectral maximum of emitted fire radiation or is close to while the spectral radiance of the background is lowest here.

The FireBIRD detection algorithm is an adaptive so called contextual algorithm witch uses the MIR, TIR and NIR and cannels witch can distinguish after the classification process between:

1. Detection of potentials hot pixels,
2. rejection class of strong sun glints or clouds,
3. rejection class of bright objects,
4. rejection class of warm surfaces and
5. rejection class of cold clouds.

This basis of the sequential algorithm was developed and tested already for the BIRD Satellite Mission. It has been modified and implemented by the FireBIRD mission for operational use. The most important principles were published in [7].

3 BIROS –Satellite Aproach

The BIROS satellite is based on a proven approach developed by DLR for the BIRD mission launched in 2001 (Briess, [1]). BIROS satellite bus uses the same technology as the TET satellite, which was successfully launched in July 2012 as the first German "Technology Test Carrier". TET was initiated and financed by the DLR Space Administration as part of the German On-Orbit Verification (OOV) programm.

At the end of 2013, TET-1 was handed over to the FireBird mission. BIROS was financed by the "BMBF" and was part of the FireBird mission from the beginning.

BIROS and TET-1 use an almost identical multispectral camera system as the main payload. (see Fig. 2). On board BIROS are several other technological experiments designed to contribute to the scientific and technological challenges of the next generation of remote sensing satellites.

High torque reaction wheels and the propulsion system system on BIROS should be emphasized. Particularly in the field of space-based disaster warning systems micro satellites are becoming more and more interesting as highly agile and accurate pointing platforms with the options of swath width extension, in the track stereo imaging, fast multi-target pointing in combination with a high flexibility to command the sensor systems to enable different data acquisition scenarios and finally a fast and flexible distribution of information to the end user on the ground.

BIROS have also a technical on-board experiment by using a hardware VHF modem. Over an ORBCOMM satellite (altitude 800 km) it could be possible to inform directly the ground users via E-Mail about an on-board detected hot-spot with the concerning geo-location e.g for fire-fighters. Here the image classification algorithms will be based on artificial neuronal networks (see paragraph 8).

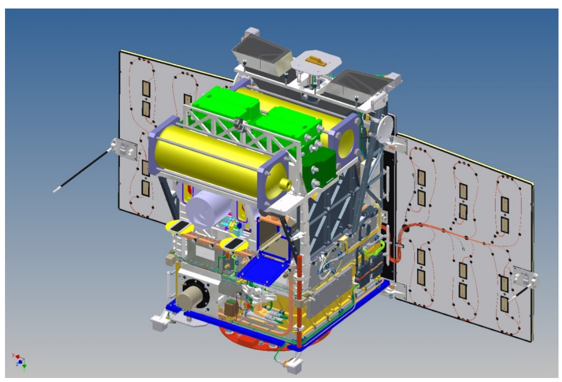

Fig. 2. BIROS Satellite with the Payload Segment

4 Operation and Data products

The operation of small satellites is differs from that of larger satellites. The FireBIRD-Constellation is a system with a ‘service on demand’ because the limited resources require a very dedicated selection of targets (data-takes). For this operation an individual data ordering process, done by a restricted group of people is necessary. The users can delegate their requests to the order group and in case of conflicts the group decides on the priority of the orders. In addition to the urgency of informing oneself about a disaster situation, the terms conflict and priority depend above all on technical parameters such as the amount of data to be stored and linked and the number of available ground stations.

Data collection planning is supported by an efficient ordering tool called SPOT, developed by DLR GSOC. The GUI of SPOT is shown in Fig. 3. The use of SPOT also makes it possible to predict future data acquisition and thus to support targeted planning of firing experiments for validation activities and other project-dependent events.

The user can choose from four standard device configurations of the camera to optimally utilize the on-board mass memory (Table 2). During night measurements (Fire Night) the visual bands can be switched off. During the day the GSD of the visual bands can be switched between 40m and 160m and for VIS1 it is possible to select which of the visual bands should be transmitted to earth. This is then a decision between the GSD and the area to be monitored on the ground.

Table 2. TET-1 and BIROS Standard Mode Configuration.

Mode	MWiR	MWIR-CAL	LWiR	LWIR-CAL	VISN	VISR	VISG	AOCS	Remark
Fire4x4	X	X	X	X	X	X	X	X	GR 160m
FireNight	X	X	X	X				X	
VISl backward	X	X	X	X	X			X	GR 40m
VISl forward	X	X	X	X			X	X	GR 40m
VISl nadir	X	X	X	X		X		X	GR 40m
VIS3	X	X	X	X	X	X	X	X	GR 40m
System Order	X	X	X	X	X	X	X	X	GR 40m

When the raw data is received, an operative processing unit generates a standard data format for the raw data. Depending on the operating mode, this L0 level contains up to 5 measurement files, two calibration files for the infrared cameras and a setting file. Based on these raw data files, the L1b standard products are generated. L1b products are radiometrically calibrated data with geographic annotation and associated metadata information. This information can be provided either in an ENVI-compliant data format or in an HDF5 format.

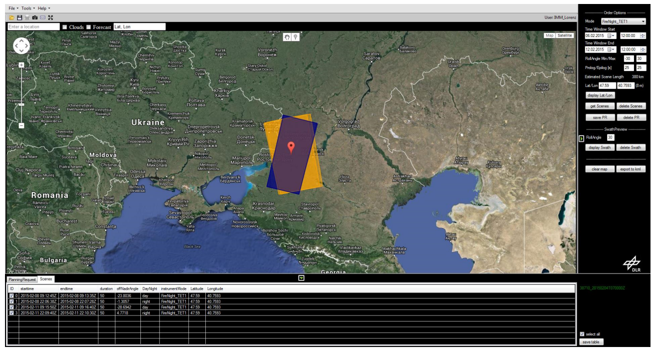

Fig. 3. the GUI of SPOT user tool

Users are informed about the status of data processing and the products can be downloaded via DLR's EOweb data archiving infrastructure.

5 Radiometric Calibration and Validation

In order to obtain scientifically usable image data, a radiometric calibration of the visible and infrared channels of the sensor must be performed. The application of the corresponding calibration data sets to raw image data is the first step in the image processing pipeline and aims at converting the digital raw image data into units of mean spectral radiation related to the spectral band of each channel. For the visible (VIS) and near-infrared (NIR) channels, calibration data sets were obtained from ground-based flat field measurements with well characterized reference sources. These data sets are applied to the incoming VIS/NIR raw data. For the mid-wave infrared (MWIR) and the long-wave-infrared channels (LWIR), calibration data are recorded during flight after data acquisition.

The calibration procedure in the case of FireBird is not a classic two-point procedure, but is based on a correlation of the detector signals with the continuous heating process of the blackbody flap in front of the IR optics (see left Figure 4 and right Figure 4).

These efforts concentrate on the development of algorithms for the reconstruction of scene signal sections with very high signal dynamics. For example, very hot temperature events on relatively cold backgrounds in the MWIR and LWIR channels can show nonlinear signal responses, especially at very low signal levels or even information loss due to optical distortion. The described calibration procedure can check the linearity of the signal responses and based on the knowledge of the spatial distribution of the incoming radiation information in the images (so-called Point Spread Functions, PSF), lost information can at least partially be estimated or reconstructed. The result is an increase of the effective dynamic range of the sensor channel. In addition, the signal dynamic range can be increased by operating the system in a special mode with reduced integration time for very hot scenes.

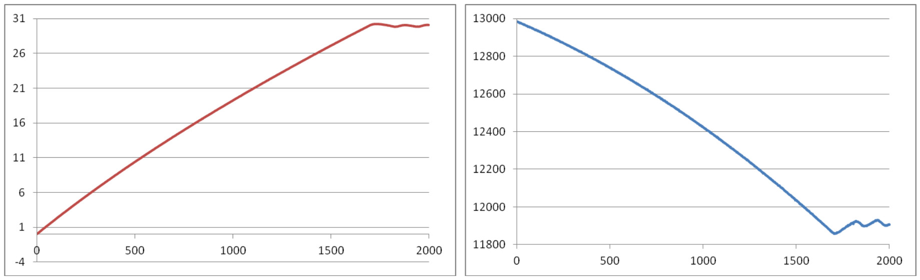

Fig. 4. Left: Calibration Black-Body-Flap Temperature curve. Right: Detector signal (DN) correlated to the Flap Temperature

6 Hot Area technology and the Bi-Spectral Algorithm

The observation of HTE and in particular of wild fires places high demands on the dynamic range which the device has to cope with. An extreme example is the observation of the Bardabunga volcano on the island (see Fig. 5) especially in the MWIR band. In this image, ice and fire stand side by side and the fire fills a series of detector pixels, which requires a very high saturation temperature. On the other hand, the glacier's low IR signal forces the detector into the non-linear operating range as described above. Both extremes can be overcome with extremely different integration intervals of the infrared detectors. This is exactly the technology implemented in FireBIRD's IR cameras. The dwell time of the IR cameras is approx. 20 ms, the integration interval for the background temperatures $\sim 20°$C is set to 6 ms. Controlling the signal levels of the first standard exposure during the readout process in real time makes it possible to initiate a second exposure with a much shorter integration interval in case of saturation. This technology allows an extremely high dynamic range to be covered.

The following pictures show an example of this unique on-board function:

In figure Fig. 6 (left) shows the data of the MWIR channel of the Portugal Forest Fire, 21 June 2017. The applied spectral radiance (right) shows the saturated pixels in one of the fire clusters (red line). The black line shows the real signal modulation of the fire cluster after the second data acquisition with the shorter integration time of 500 μs instead of 6ms. After the combination of the two data recordings on the ground, the high dynamic range is also visible in the processed fire clusters. Figure . 7 visualizes this function in detail: The left image is based on the processing without the HA processing mode. Here no inner structure of the fire cluster is visible (all pixels are saturated). The right image shows the result in HA processing mode. Here you can distinguish details of the spectral radiation within the fire clusters.

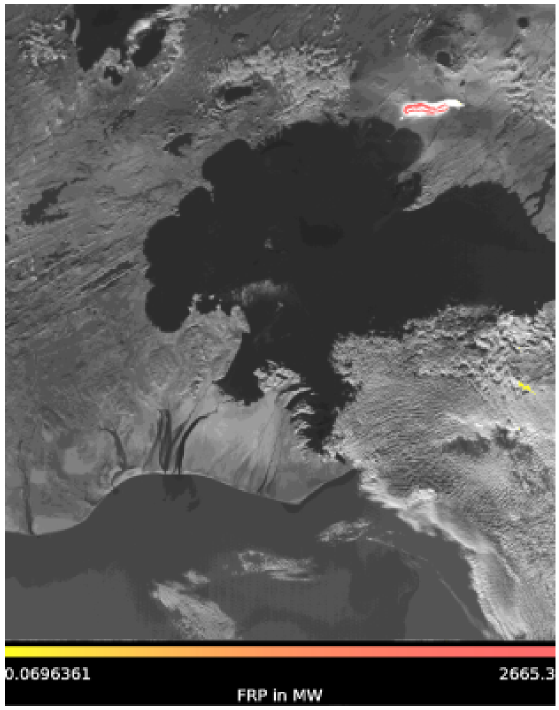

Fig. 5. Fire and Ice- The Bardabunga Volcano on Iceland

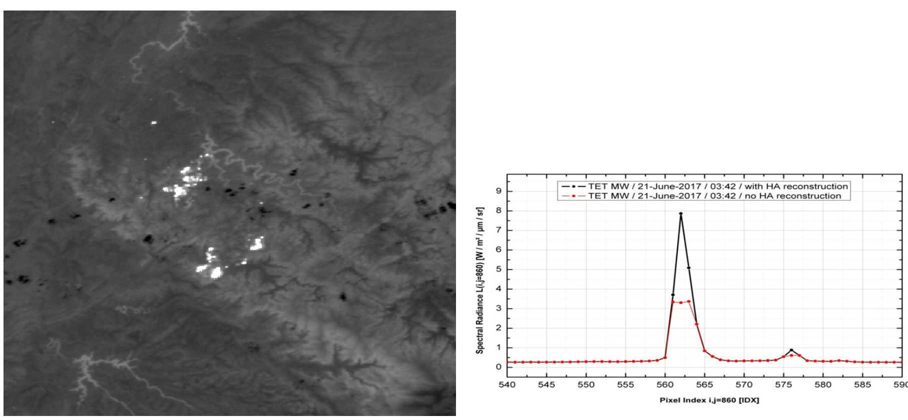

Fig. 6. Left: MWIR Portugal Forest fires, 21 June 2017. Right: MWIR spectral radiance of the image line by fire without HA mode (red-line);- with HA Mode (black-line)

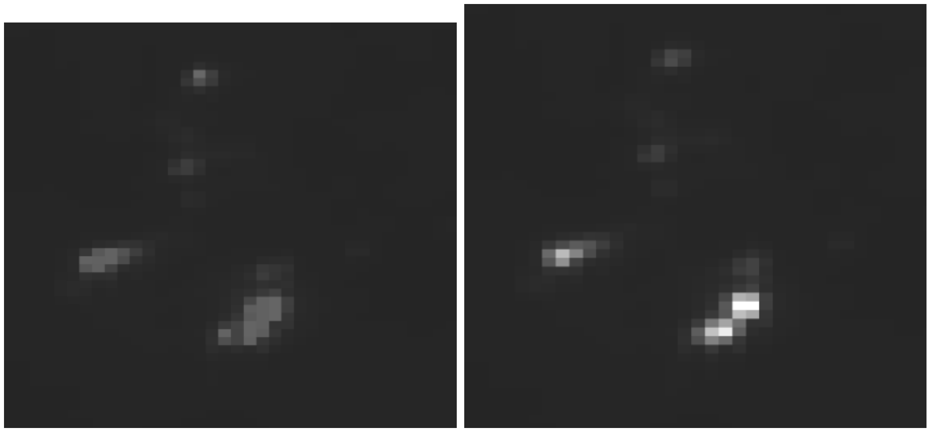

Fig. 7. Left: Fire cluster without HA-Processing. Right: Fire cluster with HA-Processing

In case of very small a hot spot which covers only a part of an image ground pixel the relating detector signal is a mix of the background temperature and the high temperature resulting in a brightness temperature of may be ∼ 40°C (for the compete pixel). After the detection of the HTE (see paragraph 2) calculation of the hot spot temperature from this brightness temperature the Dozier method (Dozier, [2]) will be applied.

In the single pixel case, the effective firing temperature T_F and the proportion of fire in the pixel q_F, which refers to the fire section A_F, are determined by solving the mixed equations for the pixel-averaged radiation in two channels:

$$L_j - L^h_{j,bg} = q_F \left(B_j \left(T^p_F \right) - L^h_{j,bg} \right) \tag{1}$$

where I_j is the atmospherically corrected radiance of a hot pixel in channel j (j = MIR and TIR) , B_j(T) is the black-body radiance in channel j as a function of temperature T, Lhj,bg is the radiance of the non-fire portion of the hot pixel to be estimated from the adjacent background pixels.

Because the MIR radiation intensity of a fire is so intense, even smaller subpixel fires will significantly affect not only the beam signal of the pixel in which the fire is actually located, but also the signal of neighboring pixels. This effect is particularly pronounced in TET-1 and BIROS images, as the double scan causes the pixels to overlap by 50%. For this reason, active fires are usually recognized as clusters of 'hot' pixels in MIR imaging, referred to here as 'hot clusters'.

The area of a hot cluster in an image should not be confused with the area of the causing fire. The figure 8 shows an example of the bush fires detected in August 2019 (data-take FBI_BIROS_20190825T020016). The left image shows the spectral radiation of the MIR channel. On the right side the calculated fire radiant power (FRP) is shown. Fig. 9 shows on the left side the position of the footprint of the data take over Brazil and on the right side the details (FRP) of some fire clusters of Fig. 8. The 'Size' column in the table 3 from the

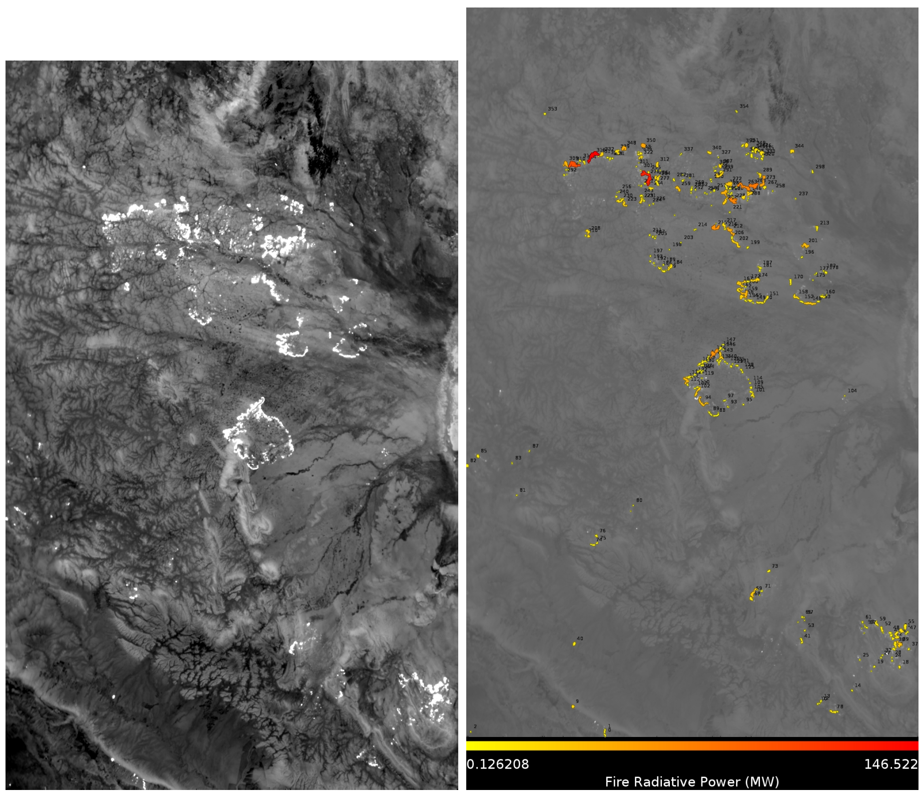

Fig. 8. left: MIR channel Brazil BIROS 25^{th} August 2019; right: Calculated FRP(Fire-Radiative-Power)

standard Level 2 data products of the scene in Fig. 8 indicates how many pixels are contained in the cluster described by a row of this table. The 'Pixel area' column indicates the area size of the affected pixels in the cluster, but the actual size of the fires is generally smaller: column A (m^2) indicates the effective size of each cluster calculated using the bi-spectral method.

This type of Level 2 data product also helps to locate the bush fire directly and only transmit relevant fire parameters to the local authorities or directly to the fire brigade.

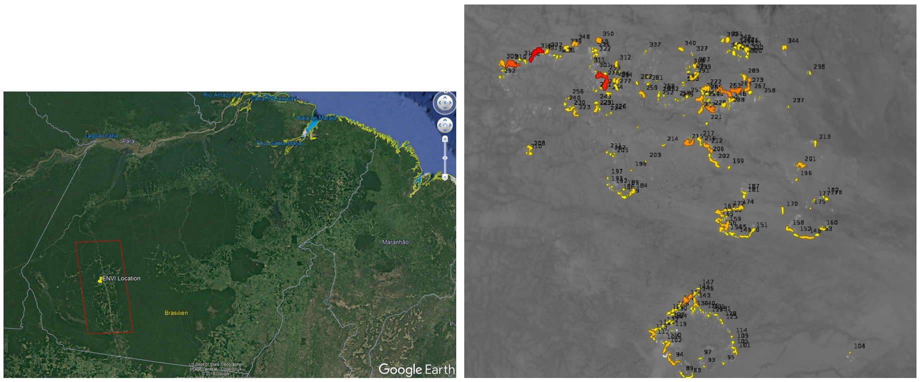

Fig. 9. left: Location of the footprint of the data-take over Brazil 25^{th} August 2019;right: details (FRP) of some fire-clusters of fig. 8

Table 3. FRP Table for a small field of view of scene FBI_BIROS_20190825T020016.

CustesNO	Size(Pixel)	PixelArea(m^2)	lat	long	FRP (MW)	T (K)	A (m^2)
0	15	496860	-18,509	-59,319	5,22	499,3	1480,6
1	21	695604	-18,496	-59,322	8,08	520,5	1941,7
2	5	165620	-18,545	-59,810	0,93	549,3	180
7	44	1457456	-18,336	-58,439	12,01	620,7	1427
8	8	264992	-18,335	-58,424	2,43	560,7	433,8
9	29	960596	-18,421	-59,463	21,71	599,2	2969,5
10	9	298116	-18,314	-58,511	2,49	505,2	672,8
12	4	132496	-18,312	-58,504	0,7	548,5	137,4
13	12	397488	-18,303	-58,500	2,82	513,1	716,7
14	9	298116	-18,250	-58,379	2,55	621,6	300,9
17	3	99372	-18,174	-58,308	0,81	493,6	241,1
18	20	662480	-18,144	-58,188	10,56	563,8	1842,8
19	12	397488	-18,153	-58,296	1,73	666,9	154,5
24	7	231868	-18,123	-58,225	0,84	693,5	63,9
25	6	198744	-18,136	-58,363	1,59	588,9	233
27	7	231868	-18,120	-58,275	1,78	523,5	418,5
28	5	165620	-18,113	-58,228	0,88	673,6	75,2

7 FireBIRD Application for wild fire monitoring

Since the IR camera systems on board TET-1 (2012) and BIROS (2017) are active, about 6000 scenes of forest fires or other HTEs, i.e. volcanoes and industrial sites such as power plants, offshore gas and oil platforms, refineries and mines, have been recorded. HTEs occur on all continents and in a wide variety of land cover types, from grasslands in South Africa, eucalyptus forests in Australia, boreal forests in Canada and even volcanoes in Iceland. In Fig. 10 an overview shows the most important placements of the worldwide data recordings with TET.

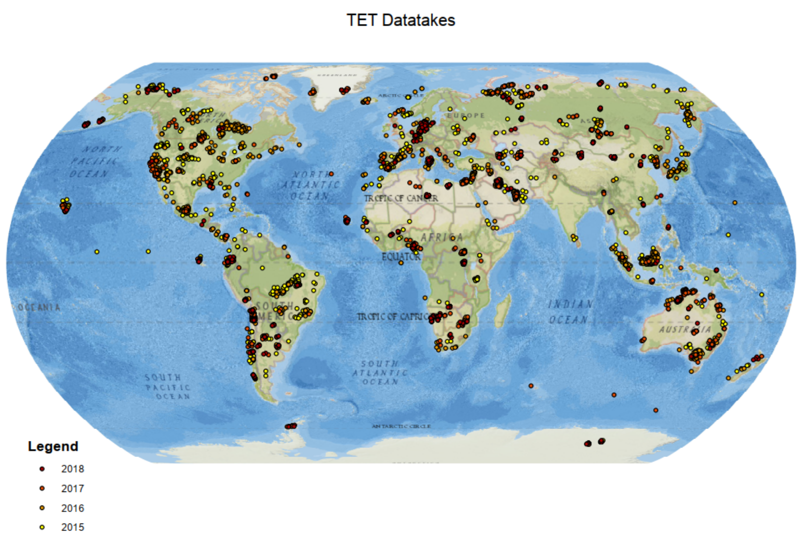

Fig. 10. Overview of the placements of the worldwide data acquisition of the FireBIRD mission until 2018

A very sad example was the devastating bushfires in the USA (Paradise California) in November 2018. TET-1 and BIROS were able to jointly demonstrate the benefits of a constellation of more than one satellite. A time series of both satellites within 5 days shows the change detection capabilities of the FireBIRD system. The Fig. 11 shows the foot-print of the data-takes. In the first days

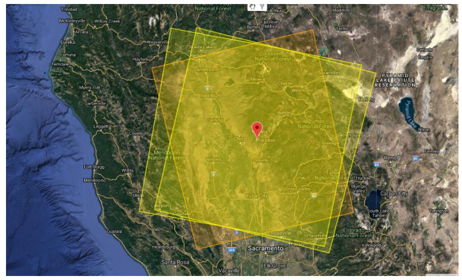

Fig. 11. Overview of the foot-print of the data-takes over Paradise (Nov 2018)

between 10^{th}, 12^{th} and $14; th$ November, the detected fire with the calculated FRP is clearly visible in the Level 2 data products (see Fig. 13).

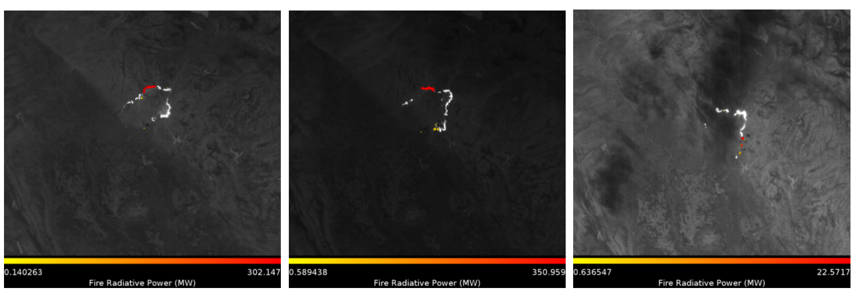

Fig. 12. Left: FRP: 10^{th} Nov/2018. Middle: FRP: 12^{th} Nov/2018. Right: FRP: TET 10^{th} Nov/2018

In the Fig. 13 the combination of 3 data-takes are shown the moving of the fire-fronts. This map projection of the fire data was developed by the DLR-ZKI (DLR-Center for Satellite based Crisis Information) especially for the regional authority and for the fire fighters.

The table 5 gives an overview of the time series of the relevant fire parameters of the several days of recorded data-takes. It shows on November 12^{th} the highest fire activation with the total size of the clusters (pixel size = 2241) and the effective size of the fires A_F =520645 m^2. On November 14^{th} the fire burns drops (A_F =88345 m^2), but the evaluated temperature is even the highest in the time series of the data acquisition. The local movement of fires between 10^{th} and $14; th$ November is illustrated in fig. 13 (Source DLR-ZKI).

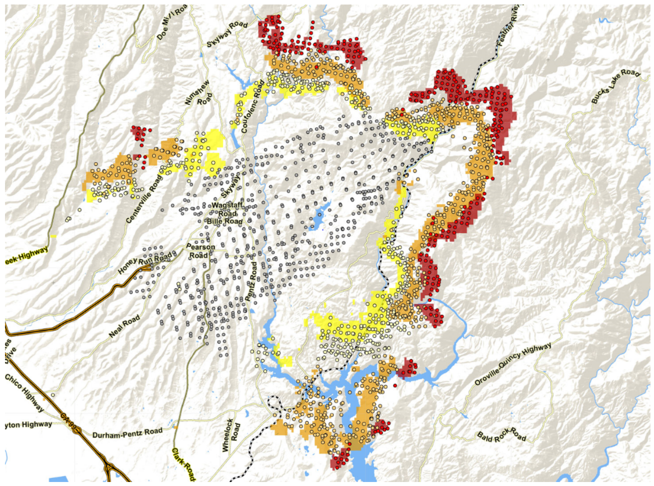

Fig. 13. Fire-Fronts: yellow (10^{th} Nov),orange (12^{th}Nov), red (14^{th} Nov); Source:DLR-ZKI

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Table 4. Overview of Level 2 data products for time series of bushfires in Paradise (USA) 2018

Date Time /h Sensor	10.11 00:19 TET/night	10.11 13:09 TET/night	12.11 13:14 TET/day	14.11 13:19 TET/day	21.11 0:17 BOS night	22.11 18:02 BOS day
FRP/MW	2792	3327	4953	1089	69.7	3.1
T_fire/K	714	672	658	752	720	891
A_F/m^2	202750	314956	520645	88345	191	52
Total Size Cluster/Pixel	1511	1738	2241	1173	188	17

8 Preparation of an on-board FireBIRD application for wildfire monitoring

In the last section, the evaluation of fire-fighting products was demonstrated using some examples. These products were processed with the FireBIRD Level 2 processor in a processing chain at the DLR ground station in Neustrelitz near Berlin after each downlink of the satellite data. The processing time for the data acquisition can vary up to several minutes depending on the number of recorded fire locations. The reason for this is that for the calculation of the fire radiant power (FRP), co-registration between the MWIR and LWIR channels must be very precise using an adaptive adaptation algorithm.

Especially for firefighters only the detection of fires with the parameters location, size and temperature is of importance. They do not need the FRP, but they need the fire information as quickly as possible. The BIROS satellite has the ability to send this type of information directly to the end user, without using the usual ground stations, via an integrated Orbcom modem. On the other hand, BIROS has a powerful on-board payload computer for image data processing.

For on-board classification to generate dedicated information for the fire brigade, neural networks are predestined to solve the problem. This has already been demonstrated on the forerunner mission BIRD (see Halle, [4]).

Before implementing an artificial neural network on the BIROS payload computer, the algorithms in MATHWORKS were simulated and evaluated offline using different data sets from the FireBIRD archive. The approach of the artificial neural network was carried out as follows: The input image of 12×12 pixels on two channels (MWIR and LWIR) passes through the 16 layers of the neural network, including three convolution layers. It is simply divided into two trained classes, either there is a fire or there is no fire. The output is the probability that the input data belongs to one of these classes.

To detect fire in an image, it is divided into overlapping $12{\times}12$ pixel patches. These are classified individually. If a fire on a patch is very likely, then the corresponding coordinates are marked on a mask and the coordinates of the pixel with the highest intensity are stored. At the end of the entire classification process, there is a mask for the entire image on which each pixel on which there is a fire is most likely marked. In addition, a table with the coordinates of possible fire clusters is created.

Table 5. Topology of the neural network with 16 layers and 2 trained classes

The training was carried out on only five different sample pictures. The training images were divided into 98420 $12{\times}12$ pixel patches. A series of patches from 2018 contained fires. Two of the images were taken in January 2018 in the Niger Delta (TET1 2018/Jan/02, TET1 2018/Jan/04) while there were some fires. Two more show wild fires in California in December 2017 (TET1 2017/Dec/10) and November 2018 (TET2018/Nov/12). The last one was recorded when a volcano erupted on the Galapagos Islands in July 2018 (TET1 2018/July/03). The ground-truth for the training was based on masks generated by the standard fire-detection-algorithm and then completed by hand.

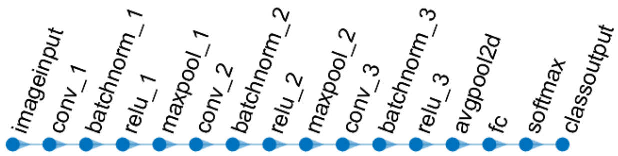

Fig. 14. Topology of the neural network

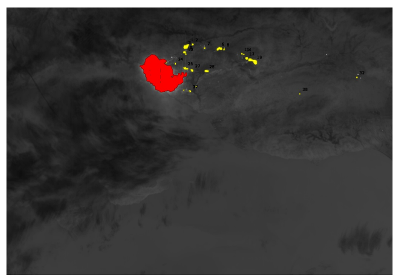

Fig. 15. TET1 2017/Dec/10

The standard FireBIRD fire-detection algorithm and the neural network were compared based on detected cluster centers and assumed cluster centers, respectively. The image section on which this comparison was performed is part of a scan showing the forest fires in the Amazon rainforest in Bolivia on 24^{th} 2019 (BIROS 2019/Aug/24). 45 common clusters were found by the algorithms and 41 by the neural network (see Table 5).

Table 5. Certain results from the cluster centre comparison

	Fire-Detection-Algorithm		Neural Net Classification	
index	mean_x	mean_y	mean_x	mean_y
89	551.5	919.1	552	919
95	627	899.3	629	900
134	571.5	801.5	571	801
144	559.9	781.9	560	783

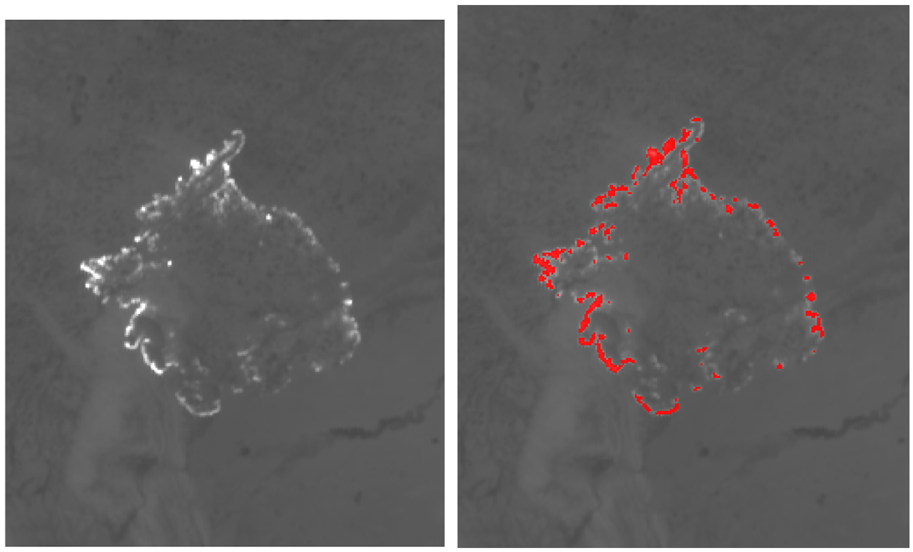

Fig. 16. left: BIROS Data-Take 2019/Aug/024; right: Results from fire-detection-algorithm

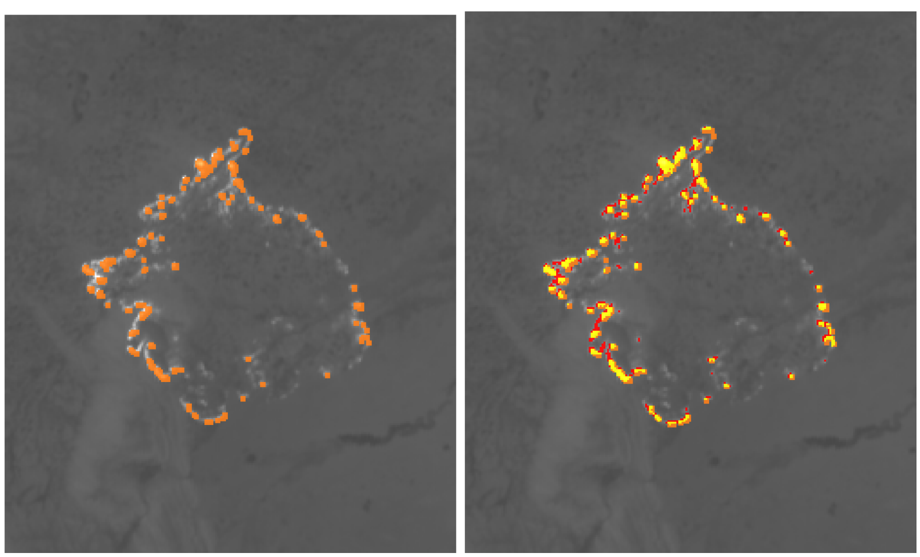

Fig. 17. left: Results of neural network classification; right: Combined result; Yellow marked pixels were found by both algorithms

9 Conclusion

In this paper we have demonstrated the capabilities of the small satellite system FireBIRD to detect high-temperature events with the multispectral infrared sensor system. The sensor system flies on the TET and BIROS satellites of an attitude of approx. 500 km SSOrbit and is capable of detecting and evaluating even small fires with low energy as well as very hot and bright fires by means of an adaptive, so-called hot area-mode when switching the integration time. The benefits of a fire constellation (at least with two satellites) were shown by means of examples of the fire catastrophe in Paradise (USA) in November 2018: Here, data recordings from TET and BIROS show the change of the fire location and the fire parameters (fire size, fire temperature and fire radiation power) during a narrow time series. Another unique feature of FireBIRD's Level 2 processing was demonstrated by a data recording of the giant Amazon rainforest fire in August 2018: By using the bi-spectral method, the effective cluster fire size (in the sub-pixel range) can be better estimated than using only the number of affected fire pixels of the cluster. For scientific users, FireBIRD standard processing offers Level 2 data products using the bi-spectral method (Dozier). In this case, the fire-radiative-power (FRP) is an important performance value as a climate-related parameter. Firefighters in particular only need information about the location and size of the fire. This information is required as soon as possible after detection and is preferably generated directly on board the satellite. Artificial neural networks are predestined for this application and can be implemented directly in hardware on board the satellites. In this paper the feasibility of the neural network classification of a "fire" class and a "non-fire" class was demonstrated (on the ground) and compared to the results of the bi-spectral method in a FireBIRD data acquisition of the large bushfire in Brazil and Bolivia in August 2019.

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